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PREVENTING OBESITY IN CHILDREN AND ADOLESCENTS*

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■ **Abstract** In this review, we address the natural history of obesity in children, the most promising family- and school-based approaches to the prevention of obesity, and the barriers and opportunities associated with secondary prevention. In childhood, the most important periods of risk appear to be the periods of adiposity rebound and adolescence. Caution regarding the period of adiposity rebound is still warranted, because it is not yet clear that early rebound is attributable to changes in body fat. Families and schools represent the most important foci for preventive efforts in children and adolescents. One productive approach is to proceed from an examination of factors that affect energy balance to the identification of more proximal influences on those factors. This approach may help to narrow the strategies necessary to prevent or treat childhood obesity. For example, television viewing affects both energy intake and energy expenditure, and therefore represents a logical target for interventions. Anticipatory guidance by pediatricians may offer an effective mechanism by which to change parental attitudes and practices regarding television viewing. A similar process is used to emphasize the potential influence of school-based interventions directed at changes in food choices and sedentary behavior.

INTRODUCTION

Between the completion of the second National Health Examination Survey (NHANES II) in 1980 and the NHANES III in 1994, the number of children and adolescents considered overweight, defined as a body mass index (BMI) ≥95th percentile for children of the same age and gender, increased by 100% in the United States (68). According to the estimates provided by NHANES III, 10%–15% of children and adolescents are overweight. Substantial increases in overweight

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occurred in all age, gender, and ethnicity groups considered. Because the gene pool within the US population did not change materially over the 15 years encompassed by the two NHANES surveys, the changes in the prevalence of overweight can be accounted for only by environmental effects on energy balance. Key mechanisms include alterations in the balance of dietary intake and physical activity levels of children and youth.

The rapid increases in the prevalence of overweight children and adolescents herald an increase in obesity-associated chronic diseases. For example, 60% of overweight 5- to 10-year-old children already have one associated cardiovascular disease risk factor, such as hyperlipidemia, elevated blood pressure, or hyperinsulinemia, and over 20% have two or more adverse cardiovascular disease risk factors (21). The incidence of type II diabetes, until recently thought to be almost exclusively an adult-onset disease, has dramatically increased among youth (19). This recent change emphasizes the fact that we cannot accurately predict all the health effects of the recent increase in prevalence of overweight children and adolescents. Although there have been some long-term follow-up studies of overweight youth (e.g. see 43), these studies are of necessity decades old and may not be generalizable to the current, unprecedented epidemic.

These data suggest that efforts to prevent obesity in children and adolescents should focus on those who are not yet overweight. However, because 10%–15% of children and adolescents are already overweight, they will also require effective treatment to prevent obesity in adulthood.

In this review, we address the natural history of obesity in children, evidence for identifiable risks, the most promising family- and school-based approaches to the prevention of obesity, and the barriers and opportunities associated with secondary prevention.

NATURAL HISTORY

Research has clearly indicated that some children and youth are at increased risk of becoming overweight adults. In this section, we review these risks while acknowledging the limited predictive value of the most commonly identified risks. For example, obesity during adolescence is the best single predictor of adult obesity (74), but this relationship is not strong for obesity during early childhood. Obesity of biological parents is also independently associated with a doubling of the risk of obesity in adulthood, among both overweight and nonoverweight children (74), independent of the age of the child.

Identifying in childhood periods of risk for adult obesity or its complications may help to narrow the focus of preventive efforts. Several years ago, we proposed that the prenatal period, the period of adiposity rebound, and adolescence represented critical periods for the development of obesity in children that persisted into adulthood (12). Each of these potential periods of risk are considered in turn.

The earliest suggestion that the prenatal period constituted a period of increased risk for the development of obesity came from follow-up studies of the offspring of mothers exposed to the Dutch famine. These studies suggested that individuals exposed in utero to famine in the first trimester of pregnancy were more likely to be overweight 18-year-olds than were individuals exposed at other times during pregnancy (47). In addition, individuals exposed to famine late in pregnancy appeared somewhat less likely to be overweight at the age of 18 years (47). Interest in these observations was heightened by the observation that low-birth-weight infants appeared to be at increased risk of the cluster of hypertension, hyperlipidemia, and glucose intolerance (syndrome X) in adulthood (3), and by the suggestion that these abnormalities were mediated by either catch-up growth (17) or abdominal fat deposition (39).

It now seems less likely that low birth weight contributes substantially to adult obesity. First, during the Dutch famine, the mean birth weight of infants exposed in the first trimester of pregnancy was approximately 2950 g, which after adjustment for the effects of weight gain and other covariates amounts to a difference of only 148 g compared with infants exposed at other times (60). Second, low-birth-weight infants appear to remain small in early childhood (63) and continue smaller until at least 26 years of age (64). Additional analyses have failed to show an increase in the prevalence of obesity in low-birth-weight infants in adulthood (9, 10; R Strauss, personal communication). Third, increased birth weight, not low birth weight, appears consistently associated with an increased BMI in adulthood (9, 10, 58, 76). Finally, even if low birth weight does contribute to obesity in adulthood, infants with birth weights lower than 2500 g do not account for more than a few percent of the general population, and thus cannot account for more than a few percent of adult obesity. Given that the prevalence of infants with birth weights in excess of 4000 g is approximately 10%, and assuming published risks of obesity are accurate (9, 10), our calculations indicate that less than 5% of adult obesity can be attributed to birth weights in excess of 4000 g. Because the prevalence of low birth weight is less than 10%, low birth weight can contribute to only a small percentage of adult obesity.

After an initial increase in the first year of life, BMI declines and reaches a nadir at 4–6 years of age. The subsequent increase in BMI is known as "adiposity rebound." Several studies have demonstrated that children with an early adiposity rebound have an increased BMI as adults (51, 46, 75). However, because no one has demonstrated that the period of adiposity rebound is associated with increased fatness, caution is still warranted with respect to the use of the term adiposity.

The final period of increased risk in childhood for adult obesity is adolescence. We have noted that the highest risk for childhood obesity that persists into adulthood occurs among overweight adolescents (74). Overweight adolescent males have an increased early mortality in adulthood (43), and overweight adolescent males and females both have an increased adult morbidity that appears independent of the effects of adolescent weight on adult weight (43). Rapid maturation in both boys and girls also appears to influence the severity of obesity in adulthood (71).

In summary, the relative contribution of each of these periods to the prevalence of adult obesity remains uncertain. The best evidence suggests that the majority of overweight adolescents go on to become overweight adults (7b, 42a). Whether adiposity rebound represents another crucial period remains uncertain because it is not clear that adiposity accounts for the early increase in BMI. Although the contribution of infants with increased birth weight is also small, because type 2 diabetes continues to increase in adults, the proportion of infants with increased birth weights will increase, and therefore the proportion of adult obesity contributed by infants with increased birth weights is also likely to increase. A final area of current research is whether age of obesity onset in childhood affects the likelihood or severity of cardiovascular disease risk factors in adulthood.

PRIMARY PREVENTION OF OBESITY

Energy balance occurs when energy intake equals energy expenditure. Energy intake in excess of energy expenditure results in weight gain, whereas energy expenditure in excess of intake produces weight loss. The only discretionary elements of energy balance are food intake and the energy spent on activity. To prevent obesity in children and adolescents, therefore, focus must be placed primarily on factors within family, school, and community environments that affect food intake and physical activity.

An article elsewhere in this book (22) focuses on environmental influences on eating and physical activity. As documented in that review, there has been a tremendous increase in recent decades in the availability of foods for consumption, as well as in advertising that promotes consumption. Furthermore, there has been a substantial rise in the amount of time children and adolescents spend viewing mass media, such as television (13, 27), and hence in the amount of their exposure to food advertising. Clearly these broad trends in our economy and society can influence energy balance of children and youth and potentially circumvent efforts by parents and such local institutions as schools to promote healthful diets and adequate levels of physical activity. The focus of this article is not how to constrain these broader forces but rather to review what is known about effective strategies for preventing obesity that can operate within our changing environments. Indeed, we should expect that broad environmental pressures for increased consumption of foods and promotion of inactive leisure pursuits will continue in the future. For example, the market for food has been expanding as obesity rates grow, perhaps in part because of the increased energy requirements associated with obesity (2). Continuing environmental pressures, however, do not mean that interventions cannot be effective in obesity prevention.

Unfortunately, few successful models exist for the prevention of childhood and adolescent obesity. Therefore, in the discussion that follows, we review the most logical targets for preventive efforts in family, school, and community settings. Because obesity is likely a consequence of pervasive influences that operate across many settings, the development of effective preventive interventions likely requires

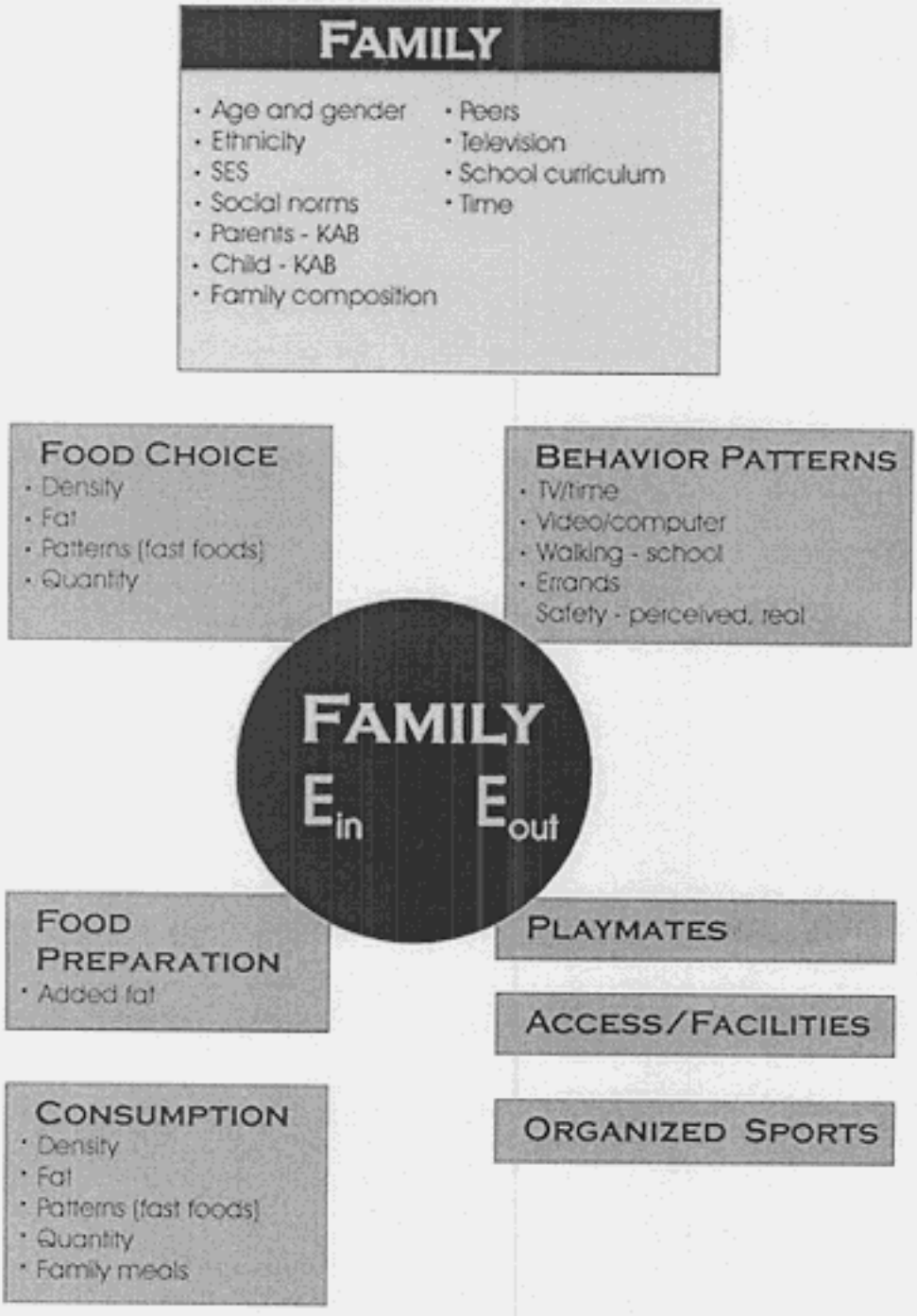
strategies that effect multiple settings simultaneously. The most effective strategies are likely to be those that affect both energy intake and energy expenditure, and that include elements common to several environmental settings. Clearly the logical models presented here are subject to modification as additional data become available. Nonetheless, they offer coherent models by which hypotheses regarding the prevention of obesity can be framed and tested.

FAMILY-BASED APPROACHES TO OBESITY PREVENTION

The logic model developed for family-based approaches to prevent obesity is shown in Figure 1. This logic model is based on what is known or can logically be assumed regarding potentially modifiable family factors that affect food intake and physical activity patterns that may promote obesity. Age and gender, ethnicity, social norms, socioeconomic class, and family composition, as well as parents' knowledge, attitudes, and beliefs (KAB) and children's knowledge, attitudes, and beliefs are characteristics that affect both food intake and physical activity. Although little is known regarding the effect these factors have on food intake or physical activity patterns of children and adolescents, efforts to change parents' knowledge, attitudes, beliefs, and practices with regard to feeding children and regulating the time children spend watching television would theoretically affect both energy intake and expenditure, and therefore represent logical targets for prevention. Likewise, school curricula may alter children's knowledge, attitudes, and beliefs and lead to changes in either food consumption or activity levels at school and at home.

Energy Intake

As shown in the family logic model, family practices related to food consumption can affect food choice, food preparation, and food consumption. Choosing to breast-feed an infant rather than use formula may prevent subsequent obesity (72). With respect to food choice, the qualities of foods brought into the home can increase caloric intake. For example, such calorie-dense foods as regular milk, sugar-sweetened beverages, high-fat foods, and fast foods represent potential sources of excess caloric intake. Likewise, consumption of fruits, vegetables, and whole grains may potentially offset high-calorie intake. In rats (53) and humans (52), exposure to a variety of foods results in an increase in caloric intake and may lead to obesity. The high rates of television advertising for food products during television programming aimed at children (25) influence food choice (38). Although no data yet link consumption of high-caloric density foods to obesity or low-caloric density foods to leanness, these consumption patterns are reasonable targets for interventions. Furthermore, these choices have potentially modifiable, proximal decision-making points, such as parental knowledge, attitudes, or beliefs, that could be influenced by physician counseling around diet. The amount of time spent watching television may be especially amenable to modification by


FAMILY
• Age and gender
• Ethnicity
• SES
• Social norms
• Parents - KAB
• Child - KAB
• Family composition
• Peers
• Television
• School curriculum
• Time
FOOD CHOICE
• Density
• Fat
• Patterns (fast foods)
• Quantity
BEHAVIOR PATTERNS
• TV/time
• Video/computer
• Walking - school
• Errands
Safety - perceived, real
FAMILY
E_{in} E_{out}
FOOD PREPARATION
• Added fat
PLAYMATES
ACCESS/FACILITIES
ORGANIZED SPORTS
CONSUMPTION
• Density
• Fat
• Patterns (fast foods)
• Quantity
• Family meals

counseling and to parental control, and may affect children's efforts to influence food purchases and choices by parents.

Family practices related to food preparation include use of fat or oil in cooking or cream, butter, margarine, or high-fat cheeses in recipes. Although the decline in fat intake in adults has occurred coincident with the epidemic of obesity, reduction of added fat during food preparation still represents a logical approach to reducing caloric intake.

The most substantial data identify family interactions related to food consumption as a logical approach to the prevention of obesity. In young children, restricted access to certain foods appears to increase preference for those foods (20). Encouraging children to eat may paradoxically decrease the intake of the food that is being encouraged (5), and efforts by parents to control the food intake of children are associated with impaired regulation of caloric intake (33). These observations suggest that a division of responsibility between parents and children around eating may have a significant impact on children's food intake. Parents should be in charge of what children are offered and when, and children should be responsible for the decision to consume what is offered or not. Anecdotal clinical data suggest that this rule effectively reduces conflicts around eating (W Dietz, personal observation) and may affect the consumption of fruits and vegetables or other patterns of food consumption. However, no data yet link alterations in these behaviors or implementation of the division of responsibility between parents and children with a lower incidence of obesity. Nonetheless, the division of responsibility between parents and children offers another potential intervention point for health care counseling.

A final factor that may influence food consumption inside and outside the home is family meals. Children who eat dinner with their families consume more fruits and vegetables, fewer fried foods at and away from home, and less soda than children who do not eat dinner with their families (26).

Physical Activity

Family practices also affect the behavior patterns associated with physical activity. Time spent viewing television has been related to the prevalence of obesity (13, 27),

Figure 1 Factors within families that may contribute to obesity or its prevention. Energy balance is depicted in the central circle. As the left side of the figure demonstrates, family practices related to food choice, preparation, and consumption may influence caloric intake. Likewise, as the right side of the figure indicates, behavior patterns, playmates, access, and organized sports can affect physical activity. In the box at the top of the figure are factors that can influence family practices related to both energy intake and energy expenditure. Television viewing by children may affect both food intake and activity. Pediatricians may be a particularly persuasive source of information that affects family knowledge, attitudes, and beliefs (KAB) related to food intake and physical activity.

and both clinical (15) and school-based studies (28, 50) have demonstrated that reductions in the amount of time spent watching television reduced weight gain in 9-year-old children (50) and reduced weight among overweight young adolescents (28). Although video and computer use might be expected to contribute to obesity because they are sedentary behaviors, no data yet support a causal relationship. A recent study indicates no relationship between video and computer use and obesity prevalence, despite a substantial relationship between level of broadcast television viewing and obesity (32). These results suggest that the effects of television advertising on obesity may be more powerful than the effects of inactivity associated with watching television. Even among 8- to 18-year-olds, who are the highest users of computers, the time spent on computers is only approximately 20% of the time spent watching television (49).

If television viewing is to constitute a realistic target for preventive efforts, alternatives to television must be available. Physical activity is likely to be increased among children with siblings and playmates or among children who live in neighborhoods where opportunities exist for safe outdoor play. Daily activities that could become part of a child's daily physical activity are walking to school or to do errands with parents. Nonetheless, data from the 1995 Nationwide Personal Transportation Survey indicate that fewer than one-third of children who live within a mile of school walk to school (S Ham, personal communication). Furthermore, although 25% of all trips in the United States are less than a mile, 75% of these trips are taken by car (P Schimek, personal communication). Pedestrian or neighborhood safety and community structure are likely factors that promote car use. For example, walking is more common in communities with centralized shopping areas and multiple routes to the same destination. However, many communities lack centralized shopping facilities or centrally located schools and offer no alternative to automobiles for running errands or transport to schools. The lack of physical activity as part of daily life, as well as the changing nature of neighborhoods and families, has contributed to the increased importance of sports participation as a source of physical activity among children and adolescents. However, no information is available to indicate the relative contribution of organized sports to fitness or daily energy expenditure in the pediatric age group.

Intervention Strategies

Several interventions have the potential to influence both family patterns of food intake and physical activity. For parents of young children, primary health care providers can offer anticipatory guidance counseling that has the potential to influence both parenting practices and the knowledge, attitudes, and beliefs of children. Although few data exist from studies of children and adolescents, studies of adults indicate that overweight patients counseled about nutrition and physical activity by a medical provider are more likely to initiate weight control efforts (24). Anticipatory guidance constitutes a routine practice in pediatrics. Reasonable targets for such counseling include the division of responsibility between parents and

children with respect to food intake and reductions in time spent watching television. Efforts to reduce food intake should focus on potential sources of excess caloric intake, such as soda, fast foods, or the calorically dense foods advertised on television. The most appropriate strategy is not to purchase these foods, rather than to have them in the house and restrict access to them. A second focus of counseling should focus on television time. As indicated above, television time affects both food intake through its influence on food choice and activity levels through displacement of other, more-energy-intensive activities. As described below, the most successful intervention models that have focused on television viewing have been school based. However, protocols to assess the effectiveness of primary counseling aimed at the control of television viewing are being developed. Because television offers a distraction for children at busy times in a parent's day, the design and implementation of incentives to reduce television time constitutes a major challenge.

Recent research has identified parental limit setting as an intervention target within families. More than half of all youth have a television set in the room where they sleep (34), and a recent study indicates that this fact strongly predicts excess television viewing, independent of other child and household characteristics. In addition, most parents set no limits on television viewing time (77). Therefore, parental limit setting in the form of excluding televisions from children's bedrooms and regulating time spent watching television to no more than 2 h per day represents an important target for intervention.

In weight-reduction protocols aimed at overweight adults, increased physical activity does not dramatically improve rates of weight loss over and above effects achieved by caloric restriction (44). Nonetheless, increased levels of physical activity may prevent weight gain and clearly improve obesity-associated comorbidities such as diabetes, hypertension, and hyperlipidemia (44). Although comparable data are lacking from children and adolescents, these results suggest that efforts to increase physical activity should become a major focus of efforts to prevent or treat obesity. How these efforts are implemented may be crucial to their success. For example, when children are encouraged to reduce television time, their attitudes toward vigorous physical activity are more positive than when they are encouraged to increase their physical activity (15). One potential explanation for this apparent paradox is that when children are urged to increase their physical activity, they perceive the encouragement as a forced choice, whereas when they are urged to reduce television time, the choice of the alternative is theirs and, therefore, more favorably perceived. These observations suggest that the most effective strategy to improve physical activity levels may be to promote strategies by parents that lead to reductions in television use by their children, such as providing alternatives, rather than to try to persuade them to become more active.

A third strategy should focus on ways to increase physical activity as part of the daily routine of children and adolescents. Several interventions have focused on increasing the frequency with which children walk to school (7). Such efforts may have additional unforeseen benefits. For example, in Chicago, where fear

of crime directed at children walking to school had increased truancy rates, the communities initiated a "walking school bus," in which parents walked with the children, picking up additional children as they went (11a). Not only did these efforts reduce truancy rates, crime in these neighborhoods decreased (7a, 36a).

SCHOOL-BASED APPROACHES TO OBESITY PREVENTION

Preventing obesity through improving diets and activity habits of children and youth is an important focus of public health efforts. School-based programs among elementary, middle, and high school students represent an important channel for behavioral change because of near-universal enrollment and the potential to affect behaviors of children that track (persist) into adolescence and adulthood (41). Coordinated school health programming provides a strong basis for implementing a range of effective school-based activities and environments to improve diet and increase physical activity (35, 42). As shown in the logic model for schools (Figure 2), a broad range of factors within schools impacts student energy balance—energy intake and energy expenditure. These causal factors range from the curriculum (e.g. is there a coordinated health program that teaches and promotes healthy diets and physical activity?), to school policies (e.g. how many days per week is physical education offered? Is there recess?), to school services (e.g. does the food service offer attractive fruits and vegetables?), to the surrounding community (e.g. is it safe to walk to school, to play in nearby parks?).

One potential dietary focus for intervention is excess consumption of sugar-sweetened beverages. Consumption has increased dramatically in past decades, coincident with the obesity epidemic (30), and there is experimental evidence for impact on weight gain (66). Children have ready access to these products in school via vending machines and cafeterias, and beverage manufacturers gear marketing strategies directly to children and adolescents (61).

In 1991, an estimated 42% of high school students were enrolled in daily physical education classes, well below the Year 2000 objective of 50% (69); a more recent report indicates that by 1997 this rate had fallen to 27% (32a). The School Health Policies and Programs Study in 1994 (35) also documents that school-based physical education in the United States was limited, that classes rarely focused on lifetime physical activity, as recommended by the Centers for Disease Control, and that only a fraction (15%) of physical education teachers required students to develop individualized fitness programs (44a).

A substantial number of school-based interventions are effective in improving diet and physical activity levels of youth, with a focus on reduced cardiovascular risk (6, 8, 18, 31, 36, 40, 45, 56, 59, 65, 70, 73). These interventions generally include classroom components, teaching students and motivating them to healthier habits, following sound theoretical models. Programs have implemented environmental changes, including reductions in fat content of school lunches (40), vending

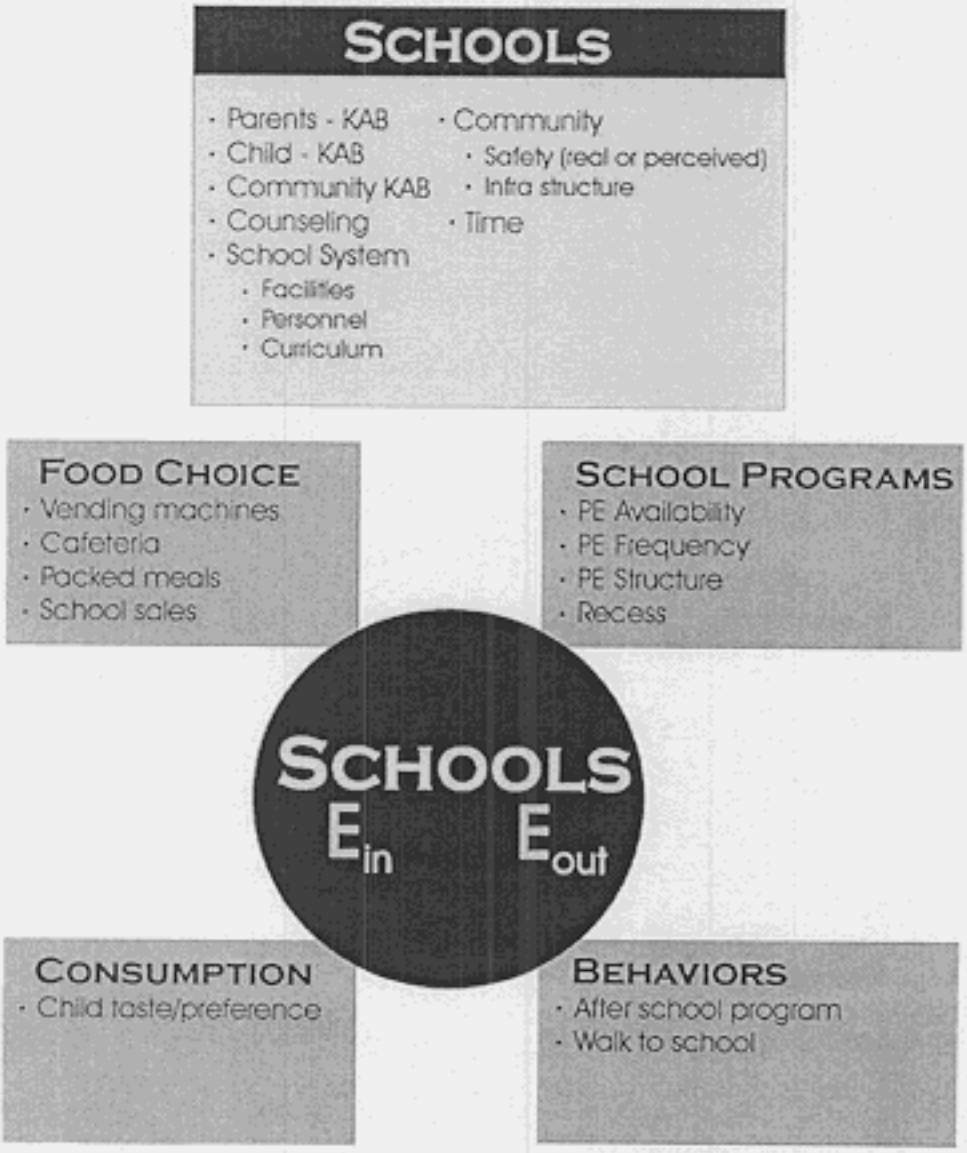


Figure 2 Factors within schools that may contribute to obesity or its prevention. The availability of food and how it is prepared can influence caloric intake. Likewise, school physical education (PE) programs offer opportunities for physical activity. Curricula can influence parent and child knowledge, attitudes, and beliefs (KAB) related to sound nutrition and physical activity. Likewise, school policies can influence how food is prepared, whether vending machines are available, and when alternative foods are available, as well as whether physical education programs are offered.

machines subsidized to promote fruits and vegetables (23), and more active physical education programming (40, 55, 56).

There have been many fewer school-based programs focused on reducing obesity prevalence. School-based interventions targeting obesity have typically treated obese students, with some studies indicating effectiveness (48, 62). Although past reviews have indicated limited effectiveness of school-wide programs in the prevention of obesity (48, 62), these studies have addressed obesity as one of several cardiovascular disease risk factors. More recent studies have focused on obesity as an end point, and effectiveness has been documented via experimental studies in high schools (37), middle schools (28), and elementary schools (50).

Two of these more recent studies indicated that reductions in television-viewing time were instrumental in producing reductions in measures of obesity, reinforcing the findings of earlier epidemiological research. The Planet Health intervention (28) in middle schools included an interdisciplinary curriculum, taught within existing math, science, language arts, social studies, and physical education classes. To improve energy balance, the curriculum emphasized a healthy diet (reduced fat and saturated fat) and reduced television-viewing time, replacing this inactive time with physical activity chosen by the student. Reductions in obesity prevalence were documented for girls, and these reductions were directly related to reductions in time spent watching television (28). The Robinson primary school intervention focused exclusively on reduction in television and video use (50). These recent studies highlight the important role of television and video viewing as a modifiable predictor of energy imbalance, and the importance of including this component in obesity prevention programs.

An important agenda for future school-based research is to identify further modifiable behavioral and environmental variables that substantially impact obesity. A continuing issue is the limited implementation of effective school-based programs. Even through programs are found to be effective, they may have limited widespread implementation. Culturally appropriate interventions may make possible both increased effectiveness and sustained implementation (11).

TREATMENT OF OBESITY IN PRIMARY CARE

Because 10%–15% of the pediatric population is overweight, effective prevention of adult disease must include treatment of those already overweight. A systematic series of studies of the treatment of childhood obesity has shown that involvement of parents and children in separate treatment groups, reduction in the intake of high-caloric density foods, and reduction in television viewing reinforced through behavior modification represent essential elements of an effective treatment program (14, 15, 29). Results from programs that employed many of these strategies showed significant differences in weight for children in the experimental group 10 years later (16).

Efforts have only begun to determine the effectiveness of these strategies in primary care settings. Several important differences exist between the primary care setting and the experimental setting in which these results were achieved. First, most pediatric settings follow the traditional medical model and are not equipped to treat children and their parents in groups. Second, few providers feel competent in the use of behavior modification strategies. Third, the small amount of time allotted for the care and counseling of patients is ill-suited to the intensive interaction necessary to identify the targets for behavioral change and to help the family implement the strategies necessary to change those behaviors. Fourth, no widely accepted successful treatment models exist. Fifth, reimbursement for the treatment of overweight children is limited, even for the most severely affected patients (67). If providers are not reimbursed for their services, little incentive exists to treat affected patients.

The contribution of pediatric obesity to adult morbidity and mortality indicates that treatment of overweight children and adolescents should become a high public health priority. Although consensus recommendations have been published for the assessment and treatment of childhood obesity (4), no studies have yet been conducted to determine how these recommendations can be best implemented in primary care settings, or how effectively these strategies achieve weight loss in affected patients. It is not clear, for example, what ages or what risk groups should be targeted. Reimbursement represents a major barrier to the implementation of weight reduction strategies in either primary or tertiary care settings because providers have no incentive to treat affected patients. Efforts to remove this barrier must be accorded a high priority before effective treatment can be widely implemented.

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